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‘Awa Root-Knot Disease

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Root-knot nematodes attack ‘awa (*Piper methysticum*) in Hawaii and throughout the Pacific. These tiny, parasitic worms cause ‘awa yields to decline up to 50 percent or more and negatively affect the taste and pharmaceutical quality of ‘awa products. This publication describes the symptoms of ‘awa root-knot disease and suggests sustainable and practical methods for its prevention and control.

Recognizing the symptoms

As the disease name suggests, diseased ‘awa roots are characteristically galled, distorted, swollen, and knotty (see photos, pages 2–3). The surface of roots may be cracked and wrinkled, with a corky texture. Diseased roots may be discolored and irregularly shaped, and young lateral roots may have stubby, swollen tips. Diseased root systems are sparse and smaller than normal. A black, putrid, watery soft-rot often develops inside severely affected roots.

Above ground, the basal stems and stump may be galled, lumpy, and swollen. The whole plant appears stunted, yellowed, and sparse. The leaves may “flag” (wilt and droop). The foliar symptoms may resemble other conditions or diseases, such as nutrient deficiency, pythium root rot (a fungus), and ‘awa dieback (a virus; see CTAHR publication PD-18, *‘Awa dieback in Hawaii*).

Cause of ‘awa root-knot disease

Several species of the plant-parasitic root-knot nematodes (*Meloidogyne* species) cause this disease in the Pacific region. To date only one of these species has been identified in Hawaii: *Meloidogyne incognita*. The parasite penetrates deep into ‘awa roots, and through its feeding on root tissues, it causes the roots to swell and become galled. In addition to disrupting root functions, this tissue damage attracts fungi and bacteria, which cause root discoloration and rot.

Disease cycle

Root-knot nematodes live in soil and plants. *M. incognita* has a very broad host range. This nematode can infect more than 700 host plant species, including many common weeds and familiar vegetable crops. The parasites hatch from tiny eggs and move through the soil in search of food. They are so small (about 1⁄50 inch, or 0.5 mm, long) that they are virtually invisible. They enter root tips and establish feeding sites deep inside the roots. Using a spear-shaped mouthpart, they withdraw nutrients from root cells. Their life span is relatively brief, lasting only several weeks or more. Each adult female will lay hundreds of eggs in the soil or root tissues. Their populations can become very large in soils where susceptible plants are grown continuously for a number of years. For a crop such as ‘awa, cultivated for 24 months or more before harvest, nematode populations can reach very damaging levels.

Root-knot nematodes do not move very far under their own power. They usually are spread by the movement of infested soil, water, and plants. They can be moved by human activity (soil on hands, boots, equipment, and tools) and transport of infested soil and infected plants from one location to another, or by flowing or draining water (irrigation and rainfall runoff).

Prevention and control

Control ‘awa root-knot dosease by using integrated cultural and preventive methods such as avoidance, sanitation, and appropriate cropping systems.

Symptom recognition

Learn to recognize the foliar and root symptoms of ‘awa root-knot and how to distinguish them from other diseases or conditions. The only characteristic symptom is the root gall. The foliar symptoms, which may mimic fertilizer deficiencies (nitrogen, potassium, and iron),

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Root symptoms
Below-ground roots infected with root-knot nematodes are swollen, rotted, discolored, and sparse (1). Healthy roots (2) are smooth, white or yellow, and numerous. The surface of infected roots (3) is galled, distorted, knotted, and rough in texture. A putrid, watery black rot often develops (4). Aerial roots (prop roots) (5) and exposed lateral roots (6) can be swollen, knobby, and cracked.

are often the first indication that there is something wrong with the roots. Periodically inspect plants in the field for symptoms. Nursery operators should inspect plant root systems for infestations before selling, distributing, or transplanting ‘awa plants.

Disease-free nurseries

Avoid propagation of ‘awa in nematode-infested soil or media. Start ‘awa node cuttings only in a sterile potting medium (e.g., cinder, peat, perlite, vermiculite). Do not use recently cultivated, agricultural field soils for rooting plants from ‘awa node cuttings. Grow young ‘awa plants on raised benches to prevent root contact with soil. Minimize water splashing during irrigation to reduce spread of contaminated soil or media between pots. Propagation and potting media can be treated with heat before use. Sufficient heat is deadly to root-knot nematodes and may be achieved with steam, fire, electricity, or solar radiation (solarization).

Prevention

Avoid planting ‘awa in fields where crops susceptible to root-knot nematodes have been cultivated recently. Prevent the introduction and establishment of root-knot nematodes into a nursery or field that is not infested. Inspect the roots of young ‘awa plants for root-knot symptoms before transplanting and, if infected, destroy them. Limit unnecessary foot or vehicle traffic into the farm. If a portion of an ‘awa farm becomes infested with root-knot nematodes, perform all farm operations in that section last rather than first to minimize the dispersal of nematodes on field implements, tractors, or vehicles.

Stem and stump symptoms
Root-knot nematodes cause galling and distortion of ‘awa’s basal stem and stump. At left (7) the white circle highlights swollen, galled, and knotty tissues. Stem galls (8, 9) can result from mounding up with nematode-infested soil.

Soil and media testing
Assay soil and media for the presence and quantity of root-knot nematodes by submitting soil samples to a private laboratory or to the CTAHR Agricultural Diagnostic Service Center (via the nearest Cooperative Extension Service office). An appropriate soil sample consists of a representative, composite sample taken from a depth of about 6 inches in areas to be planted.

Preplant nematicides
Preplant soil fumigants, soil sterilants, or other registered nematicides may be used to reduce initial nematode populations to nondamaging levels before planting. There are no postplanting nematicides registered for use on ‘awa in the United States.

Sanitation
Sanitation means the decontamination of objects used in ‘awa cultivation. Tools (shovels), propagation materials (pots), clothing (boots), and farm vehicles (tires) may be a source of nematodes when they come into contact with nematode-infested soils. Soil should be removed from these objects with a strong spray of water followed by cleaning with a solution of household bleach (1 part bleach in 9 parts water).

Irrigation and fertilizer management
‘Awa plants may wilt due to nematode attack even though soil moisture is adequate. Because the damaged roots are so inefficient in the uptake of water and nutrients, some additional water and fertilizer may reduce wilting and improve plant growth. However, avoid excessive application of irrigation and fertilizer. Overirrigation can help to spread root-knot nematodes and increase nematode numbers by shortening their life cycle. Overfertilizing can lead to rotting of infected roots, followed by plant decline and death.

Rogue disease plants
Rogueing is the removal of diseased plants from nurseries and fields. This practice is best for new farms or when disease is detected early. Rogue and burn or discard diseased ‘awa plants in areas or farms where new outbreaks of root-knot disease are discovered. This will prevent or minimize the spread of nematodes from diseased plants to healthy plants along rows or between farms and nurseries. If root-knot disease is already well established and severe, roguing will not help to stop the disease from spreading.

Composting and soil amendments
Organic soil amendments deter nematodes. Preplanting and postplanting applications of organic soil amendments such as composted plant materials (e.g., macadamia husks) and composted chicken manure provide some nematode control while contributing plant nutrients and encouraging healthy plant growth. Organic amendments promote biological control of root-knot nematodes by

providing a favorable environment for parasites and other organisms that compete with the nematodes.

Weed control

Eradicate all weed hosts of root-knot nematodes while growing 'awa and during fallow periods. Submit root samples of weeds for laboratory assay for nematodes. Although visual inspection of weed roots for the characteristic galls may be sufficient to determine the risk, some weed hosts have much smaller galls than the swellings commonly observed on 'awa roots.

Appropriate cropping systems

Diversified crop interplantings and crop rotations can interrupt the spread, reproduction, and survival of nematodes. Consider using a multicropping system, combining or alternating 'awa with plants that are immune or highly resistant to root-knot nematodes. Sunn hemp (*Crotolaria juncea*), for example, planted in strips between rows or blocks of 'awa, is a suitable companion crop that is not a good root-knot nematode host. Due to the wide host range of root-knot nematodes, use care in selecting companion species.

Basket planting

Basket planting is the cultivation of individual 'awa plants in above-ground, cylindrical planters or baskets. The baskets are filled with a mixture of nematode-free growth media such as volcanic cinder, treated soil, and compost. The baskets are usually constructed from fence wire and weed mat. Basket planting reduces the probability of infection by root-knot nematodes.

Early harvest

The severity of root-knot disease tends to increase over time. Thus, early or on-time harvest is recommended for plants that have root-knot disease or for fields that have heavy infestations of root-knot nematodes. Delayed or late harvest may result in severely rotten roots and significant yield loss. Periodic root sampling in the months before harvest will show if early harvest is warranted.

Hydroponic systems

Growth of 'awa in soilless media or hydroponic systems can reduce the potential for establishment of root-knot nematodes. It is important to ensure that a nematode-free source of water is used and that the hydroponic solution is protected from contamination with soil or nematode-infested tools and debris.

Host-free fallow

Fields that are heavily infested with root-knot nematodes should be placed in bare or host-free fallow for a minimum of a year before replanting 'awa. The fallow is not very effective unless weed hosts of *M. incognita* are kept from growing.

Minimize postharvest rotting

Saprophytic fungi, such as *Fusarium* species, and bacteria tend to colonize the cracked and swollen 'awa roots that have been infected by root-knot nematodes. Therefore, process and dry all nematode-infected roots quickly after harvest to minimize rot. Store the dried or processed root material in location with low humidity.

Host resistance

At present, no 'awa varieties are thought to be resistant to root-knot nematodes.